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AGRICULTURAL MEMORANDUM NO 924 S N WASS SEPTEMBER 1981

ESTIMATING GLASSHOUSE HEATING EFFICIENCY

SUMMARY

Measurement of glasshouse heating system efficiency is usually limited to that of the boiler by measuring the temperature and CO_2 content of the flue gases. Comparison of weekly fuel readings with numerical model estimates have led to a method of assessing the overall efficiency of a holding and of monitoring weekly performance. A development of this method has made it possible to cost the environmental control of botrytis.

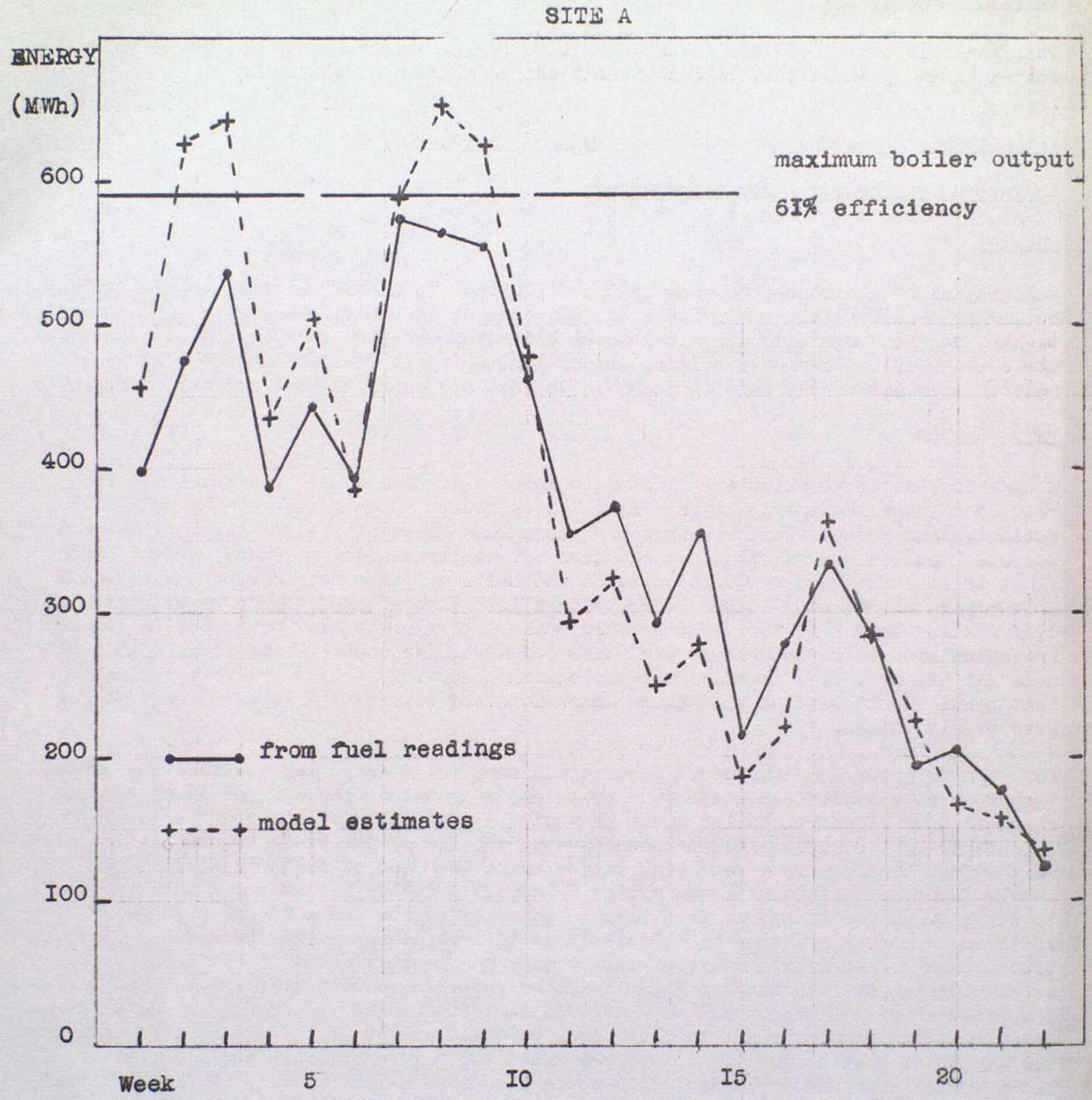
INTRODUCTION

A numerical model to calculate glasshouse heat requirements has been developed from results of an NIAE experiment in a single span house. Comparisons of the models estimates and growers fuel readings have been made for the first 22 weeks of 1981. The model solves the heat balance equation between transmission losses, ground heat flux, solar contribution, CO_2 production and heating system requirements (Wass). In this paper transmission losses refer to heat lost through the glasshouse skin and distribution losses to that lost between boiler and glasshouse. Transmission losses are calculated from temperature and windspeed and solar contribution from sunshine data all measured at a standard meteorological observing station. Hourly estimates of heat requirement based on glasshouse dimensions and temperature regimes are summed to give weekly totals.

Four tomato growers in the South West region supplied weekly fuel readings and target temperatures and although glasshouse types and temperature regimes varied considerably they all used a central boiler house providing a good test for the model. Total calculated heat requirement expressed as a percentage of the total net calerific value of the fuel burnt gives a weighting factor which was used to scale the individual weekly figures. Although the weighting factor is strictly a conversion from the models to the growers use of energy it will be seen that it provides a useful measure of efficiency. Any difference in efficiency is then due to operating procedure, distribution losses, transmission coefficients or the representativeness of the local meteorological station but not glass to floor ratio or temperature regime. For instance a multi-span single glasshouse may have the same floor area as several separate houses. Because of its reduced glass to floor area we would expect it to be more efficient in the amount of heat needed to achieve the same temperature regime. Model estimates based on the same meteorological data would also show a lower heat requirement but if transmission and distribution losses on both holdings were similar then the weighting factors should be the same. Any difference would thus be due to operating procedure such as a failure to maintain target temperatures.

Statistics for the 4 sites, arranged in order of size, are shown below and a brief discussion follows:-

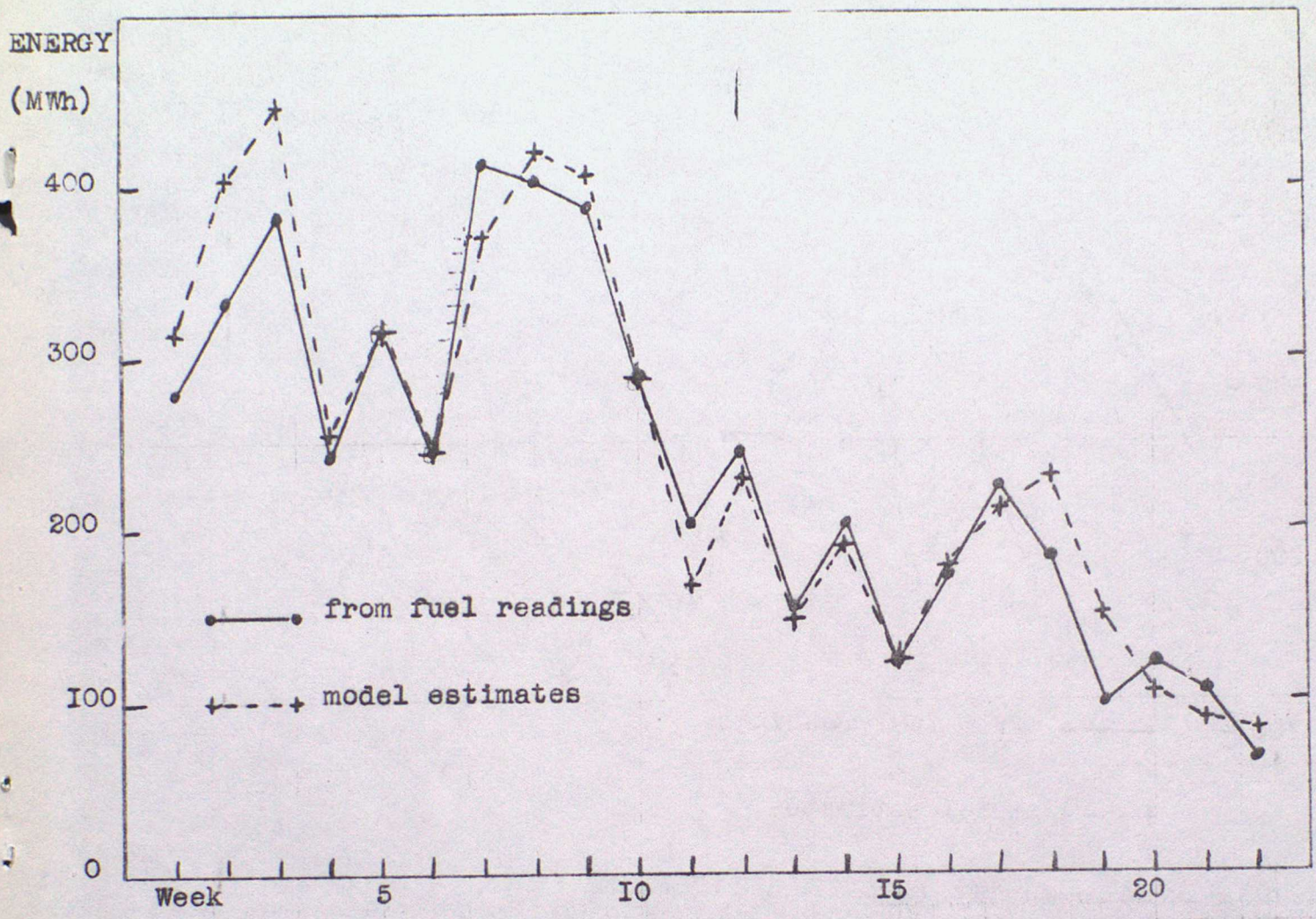
Glasshouse Site	Distance from Met station KMS	Comparison between estimated and actual energy requirements				
		Correlation Coefficient	No of weeks	r.m.s error Mwh	r.m.s error Litres	Efficiency %
A	7	0.97	19	47	7149	61
B	3	0.97	19	23	2808	76
C	10	0.92	12	29	3287	81
D	21	0.93	19	19	2351	75



SITE A

Here the analysis has highlighted 2 points of interest. Firstly the difference between measured consumption and calculated consumption in weeks 1-3 and 8-9 are due to the boilers being unable to maintain an average weekly heat loss of more than 590 MWh and so there would certainly have been periods in those weeks when target temperatures were not achieved. No internal temperature records were kept on this site but the shortfall is equivalent to 2° - 3°C on average. Secondly taking only the weeks when boiler output was adequate the conversion factor is only 56%, a figure consistent with the type of boiler and poor distribution system on this holding.

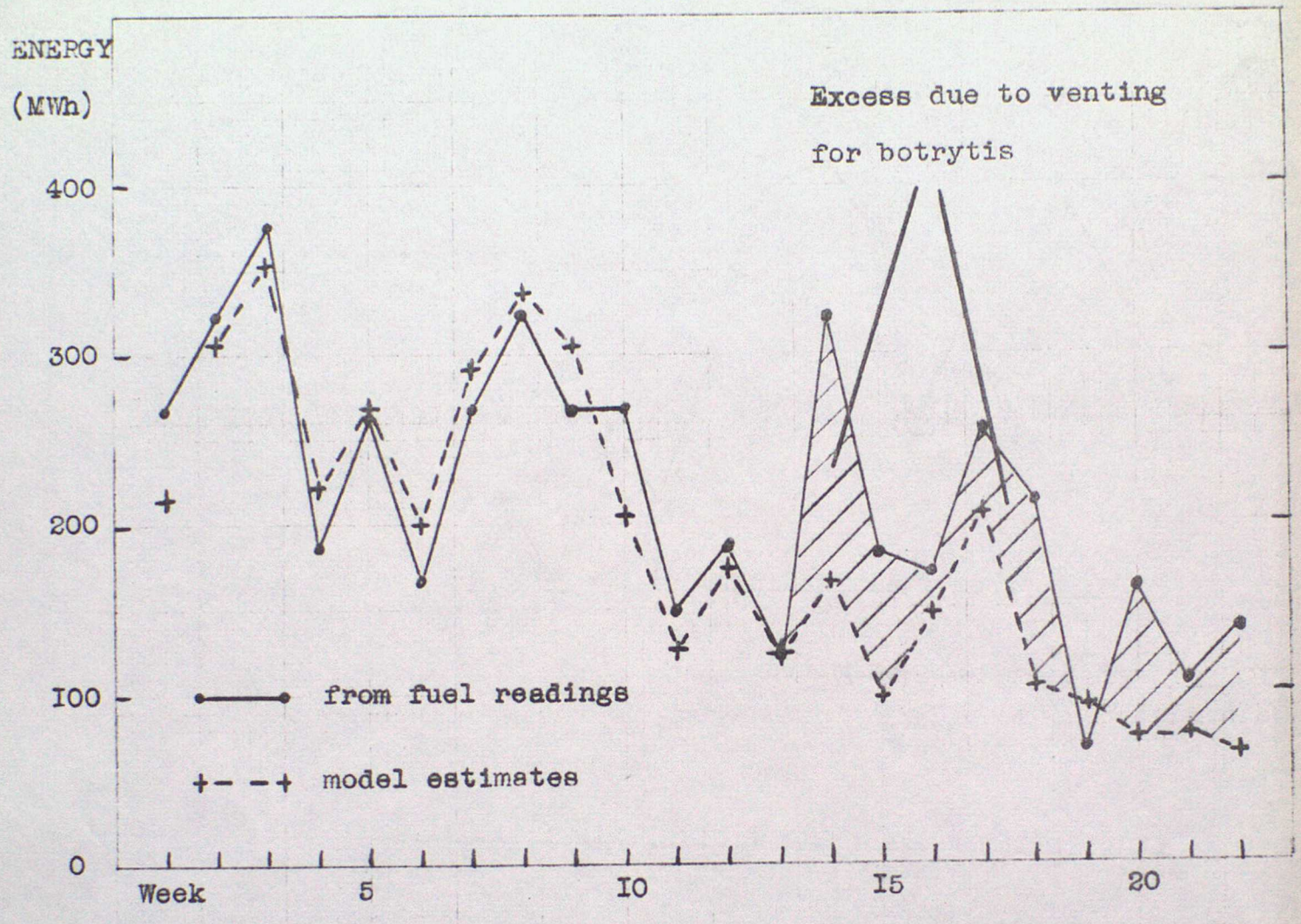
SITE B



SITE B

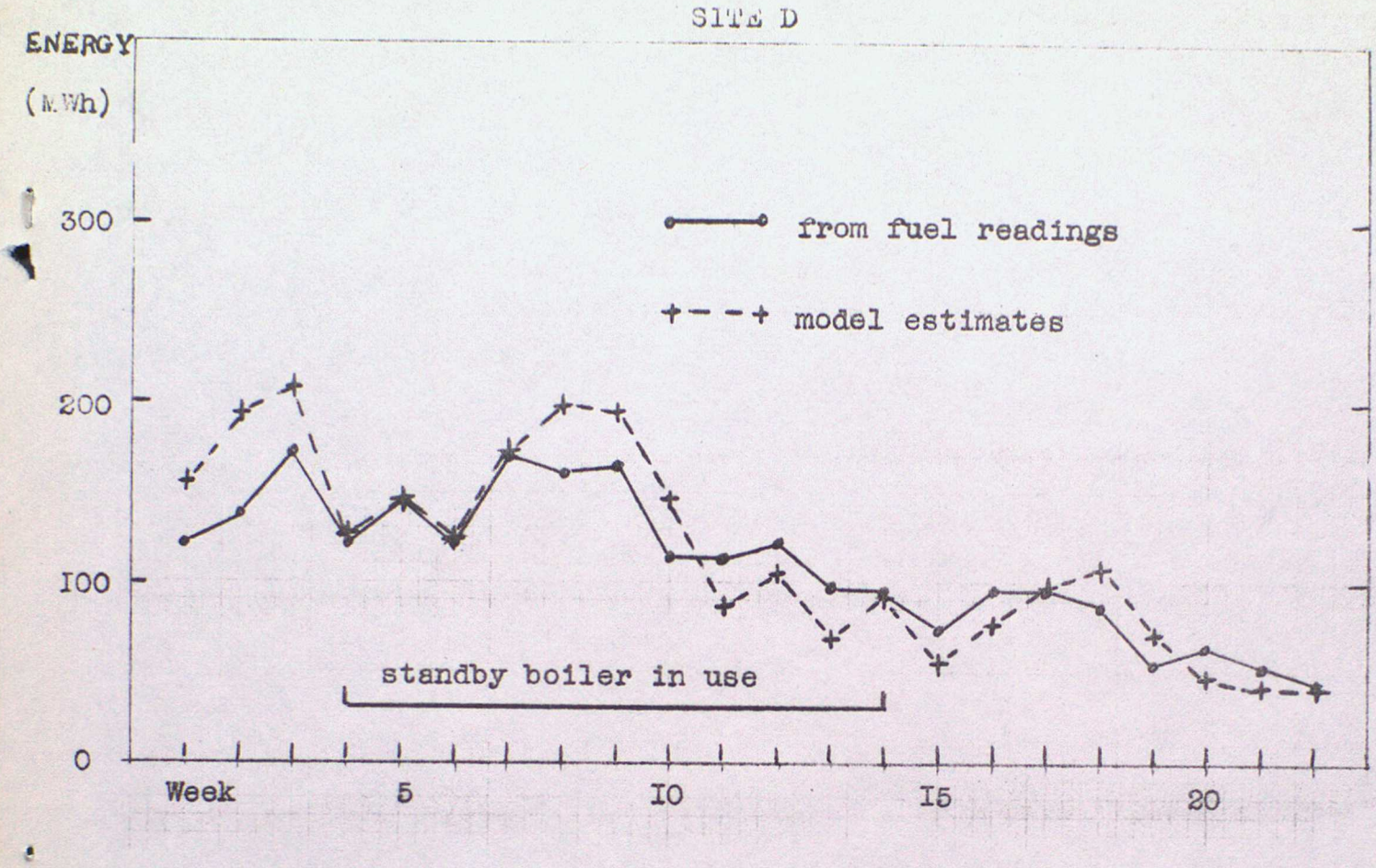
This is a well planned modern glasshouse site very close to the meteorological station used for calculating heat losses and so gives a good guide to correction factors. Estimated requirements are a very good fit to fuel readings except in the first 3 weeks. Although the grower reported that target temperatures were not achieved until an hour or so after daybreak this would only reduce the model estimates by about 8 MWh in those weeks. Boiler rating was such that a temperature lift of about 30°C was possible. Bubble insulation was fitted around the largest block during the second week would have reduced the transmission coefficient. Taking the remaining 19 weeks the overall efficiency is about 75% with a correlation coefficient of 0.97 and it is suggested that this figure be taken as a standard.

SITE C



SITE C

Only 12 weeks data could be used for this site since no temperatures were measured in one house in the first week and since forced venting had to be used from week 14 in some houses due to botrytis infection. This grower maintained temperature records in most houses which leads to a good fit from weeks 2-13 with a r.m.s. error of 3287 l which compares well with fuel use being reported to within 2500 l. The nearest meteorological station was not considered very representative even though readings were corrected for altitude and exposure (Smith) and this may be reflected in the highest conversion factor of 81%. However botrytis may have been encouraged by a well sealed house which would result in low transmission coefficients and hence a high conversion factor. Cost of venting for botrytis control is shown by the differences between estimated and recorded fuel use between weeks 13 and 42, totalling 490 MWh which is equivalent to over 56,000 l of oil.



SITE D

All calculations are based on target temperatures which the grower reported as not being reached in the first 3 weeks. Although a standby boiler was also used between weeks 4 and 14 the model still over estimates weeks 8 and 9 although it is possible that temperatures were also not achieved over this period. Fuel use was usually reported to the nearest 2000 l and so a r.m.s. error of 2351 is considered reasonable. An efficiency of around 70% is usually accepted for conversion of fuel to useful energy (80% boiler efficiency and 10% distribution losses) and thus a conversion factor of 75% shows his performance to be better than the model. Polythene sidewalls have been fitted around most of the houses and it should be expected that these would reduce transmission losses.

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REFERENCES

1. Smith L P (1976) Technical Bulletin 35. The Agricultural Climate of England and Wales.

2. Wass S N (1980) The Solar contribution to Glasshouse Heating. Agricultural Memorandum No. 903.